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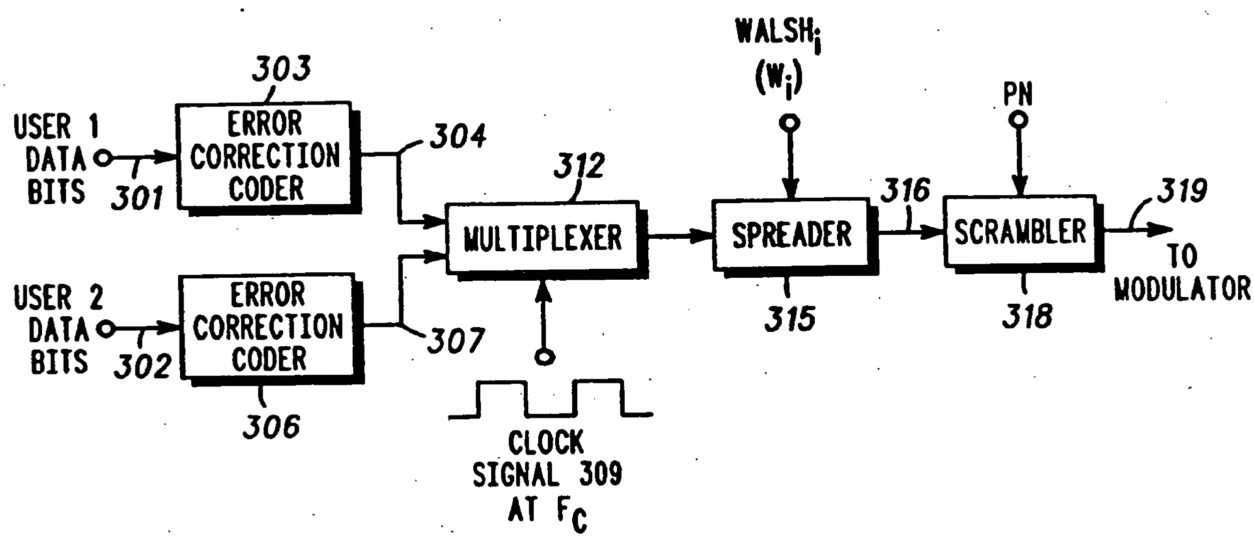

(57) **Abstract**

A communication system time division multiplexes the use of spreading codes. The communication system accepts information (301, 302) from at least two users and codes each users information utilizing error correction coders (303, 306). The coded information is then time multiplexed by a multiplexer (312) into timeslots. The output of the multiplexer (312) is spread by a common spreading (Walsh) code, scrambled with a pseudo-noise sequence, and conveyed to a modulator for transmission. In this manner, information for two users may be transmitted utilizing only a single spreading (Walsh) code.

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METHOD AND APPARATUS FOR TIME DIVISION MULTIPLEXING THE USE OF SPREADING CODES IN A COMMUNICATION SYSTEM

Field of the Invention

The invention relates generally to communication systems, and more particularly to time division multiplexing the use of spreading codes in such communication systems.

Background of the Invention

Communication systems take many forms. In general, the purpose of a communication system is to transmit information-bearing signals from a source, located at one point, to a user destination, located at another point some distance away. A communication system generally consists of three basic components: transmitter, channel, and receiver. The transmitter has the function of processing the message signal into a form suitable for transmission over the channel. This processing of the message signal is referred to as modulation. The function of the channel is to provide a physical connection between the transmitter output and the receiver input. The function of the receiver is to process the received signal so as to produce an estimate of the original message signal. This processing of the received signal is referred to as demodulation.

Analog and digital transmission methods are used to transmit a message signal over a communication channel. The use of digital methods offers several operational advantages over analog methods, including but not limited to: increased immunity to channel noise and interference, flexible operation of the system,

common format for the transmission of different kinds of message signals, improved security of communication through the use of encryption, and increased capacity.

To transmit a message signal (either analog or digital) over a communication channel having an assigned channel bandwidth, the message signal must be manipulated into a form suitable for efficient transmission over the channel. Modification of the message signal is achieved by means of a process termed modulation. This process involves varying some parameter of a carrier wave in accordance with the message signal in such a way that the spectrum of the modulated wave matches the assigned channel bandwidth. Parameters of a carrier wave that can be varied include amplitude, frequency, and or phase. Correspondingly, the receiver is required to recreate the original message signal from a degraded version of the transmitted signal after propagation through the channel. The re-creation is accomplished by using a process known as demodulation, which is the inverse of the modulation process used in the transmitter.

A spread spectrum system provides, among other things, robustness to jamming, good interference and multipath rejection, and inherently secure communications from eavesdroppers. In a spread spectrum system, a modulation technique is utilized in which a transmitted signal is spread over a wide frequency band within the communication channel. The frequency band is much wider than the minimum bandwidth required to transmit the information being sent. A voice signal, for example, can be sent with amplitude modulation (AM) in a bandwidth only twice that of the information itself. Other forms of modulation, such as low deviation frequency modulation (FM) or single sideband AM, also permit information to be transmitted in a bandwidth comparable to the bandwidth of the information itself. However, in a spread spectrum system, the modulation of a signal to be transmitted often includes taking a baseband signal (e.g., a voice channel) with

a bandwidth of only a few kilohertz, and distributing the signal to be transmitted over a frequency band that may be many megahertz wide. This is accomplished by modulating the signal to be transmitted with the information to be sent and with a wideband encoding signal (commonly known as a spreading code).

Thus, a spread spectrum system must have two properties: (1) the transmitted bandwidth should be much greater than the bandwidth or rate of the information being sent and (2) some function other than the information being sent is employed to determine the resulting modulated channel bandwidth.

The essence of the spread spectrum communication involves expanding the bandwidth of a signal, transmitting the expanded signal and recovering the desired signal by remapping the received spread spectrum into the original information bandwidth. Furthermore, in the process of carrying out this series of bandwidth trades, the purpose of spread spectrum techniques is to allow the system to deliver error-free information in a noisy signal environment.

With digital communication, user information such as speech is encoded into sequences of binary information. This encoding is convenient for modulation and is easily error-correction coded for transmission over a potentially degrading communication channel. Such binary information is particularly amenable to transmission using "direct sequence" spread spectrum modulation. With direct sequence, digital information is spread with a spreading code whose bit rate is much higher than the information signal itself. Although the spreading can be accomplished by several methods, the most common is to add each bit of information (generally after appropriate error correction coding) to a sequence of bits of the spreading code. Thus as desired for the spreading process, many bits are generated for each coded information bit that is desired to be transmitted.

Advantages from direct sequence spread spectrum communication systems are obtained since the receiver is knowledgeable of the spreading code used to spread the user signal. As is well known in the art the receiver, after appropriate synchronization to the receive signal, is able to decode the wide bandwidth spread signal using a replica of the spreading sequence. Another advantage of spread spectrum communication systems is the ability to provide multiple access capability. Specifically, cellular telephone communication systems have been designed to incorporate the characteristic of communicating with many remote units on the same communication channel.

One type of multiple access spread spectrum communication system utilized with direct sequence spread spectrum is a code division multiple access (CDMA) communication system. In a CDMA communication system, communication between two communication units is accomplished by spreading each transmitted signal over the frequency band of the communication channel with a unique user spreading code. As a result, transmitted signals are in the same frequency band of the communication channel and are separated only by unique user spreading codes. Particular transmitted signals are retrieved from the communication channel by despreading a signal representative of the sum of signals in the communication channel with a user spreading code related to the particular transmitted signal which is to be retrieved from the communication channel. Specially suited spreading codes may be employed to reduce the interference created by the sum of all the other signals present on the same channel. Orthogonal codes are typically used for this purpose, and of these, the Walsh codes are most common.

Many digital cellular telecommunication systems have the ability to provide reduced data rate traffic channels. These systems have traffic channels designed to operate at a particular data rate

and also have reduced data rate traffic channels which provide more traffic data capacity than that at the designed data rate. This increased traffic data capacity in achieved at the cost of reduced quality and/or increased complexity speech coders and decoders.

Thus, a need exists for a communication system which provides increased or high data rate traffic channels which allow for transmission of data at a rate higher than the designed data rate traffic channels without altering current hardware designs and air-interface standards.

Brief Description of the Drawings

FIG. 1 generally depicts, in block diagram form, a prior art spread spectrum transmitter.

FIG. 2 generally depicts, in block diagram form, a prior art spread spectrum transmitter for transmitting information for two users.

FIG. 3 generally depicts, in block diagram form, a preferred embodiment spread spectrum transmitter which performs time division multiplexing of spreading codes for two users in accordance with the invention.

FIG. 4 is a chart showing how a spreading (Walsh) code is shared amongst two users to provide a rate 1/2 capability for each user in accordance with the invention.

Detailed Description of a Preferred Embodiment

A communication system time division multiplexes the use of spreading codes. The communication system accepts information (301, 302) from at least two users and codes each users information utilizing error correction coders (303, 306). The coded

information is then time multiplexed by a multiplexer (312) into timeslots. The output of the multiplexer (312) is spread by a common spreading (Walsh) code, scrambled with a pseudo-noise sequence, and conveyed to a modulator for transmission. In this manner, information for two users may be transmitted utilizing only a single spreading (Walsh) code.

Many embodiments exist. In the preferred embodiment, first (USER 1) and second (USER 2) user information 301, 302 is multiplexed in at least partially non-overlapping time periods by a multiplexer 312 to produce multiplexed first and second user information. The multiplexed first and second user information is then spread with a common spreading code. In an alternate embodiment, the first and second user information 301, 302 may first be spread by a common spreading code, then multiplexed into at least partially non-overlapping time periods. In either embodiment, the common spreading code is a common orthogonal spreading, and typically a Walsh code. As one of ordinary skill in the art will appreciate, the first and second user information may be coded or uncoded. Any embodiment chosen may be implemented in either a base-station or a mobile unit which is compatible with the spread spectrum communication system.

Referring now to FIG. 1, a prior art spread spectrum transmitter is shown. In the prior art spread spectrum transmitter of FIG. 1, USER 1 data bits 100 are input to an encoder 102 at a particular bit rate (e.g., 9.6 kbps). USER 1 data bits 100 can include either voice converted to data by a vocoder, pure data, or a combination of the two types of data. Encoder 102 convolutionally encodes the USER 1 data bits 100 into data symbols at a fixed encoding rate. For example, encoder 102 encodes received data bits 100 at a fixed encoding rate of one data bit to two data symbols such that the encoder 102 outputs data symbols 104 at a 19.2 ksym/s rate.

The encoder 102 may accommodate the input of USER 1 data bits 100 at variable lower rates by encoding repetition. That is, when the data bit rate is slower than the particular bit rate at which the encoder 102 is designed to operate, encoder 102 repeats USER 1 data bits 100 such that the USER 1 data bits 100 are provided the encoding elements within the encoder 102 at the desired full rate. For example, if the input rate were 1/2 rate, the information would be repeated twice (i.e., to simulate a full rate). If the input rate were 1/4 rate, the information would be repeated four times, and so on. Thus, the encoder 102 outputs data symbols 104 at a the same fixed rate regardless of the rate at which data bits 100 are input to the encoder 102.

The data symbols 104 are then input into an interleaver 106. Interleaver 106 interleaves the input data symbols 104. The interleaved data symbols 108 are output by the interleaver 106 at the same data symbol rate that they were input (e.g., 19.2 ksym/s) to one input of an exclusive-OR combiner 112.

A long pseudo-noise (PN) generator 110 is operatively coupled to the other input of exclusive-OR combiner 112 to enhance the security of the communication channel by scrambling data symbols 108. The long PN generator 110 uses a long PN sequence to generate a user specific sequence of symbols or unique user code at a fixed rate equal to the data symbol rate of the data symbols 108 input to exclusive-OR gate 112 (e.g., 19.2 ksym/s). The scrambled data symbols 114 are output from exclusive-OR combiner 112 at a fixed rate equal to the rate that data symbols 108 are input to the exclusive-OR combiner 112 (e.g., 19.2 ksym/s). Scrambled data symbols 114 are then input into exclusive-OR combiner 118.

A code division channel selection generator 116 provides a particular predetermined length spreading (Walsh) code to another input of exclusive-OR combiner 118. The code division channel selection generator 116 can provide one of 64 orthogonal

codes corresponding to 64 Walsh codes from a 64 by 64 Hadamard matrix, wherein a Walsh code is a single row or column of the matrix. Exclusive-OR combiner 118 uses the particular Walsh code input by the code division channel generator 116 to spread the input scrambled data symbols 114 into Walsh code spread data symbols 120. The Walsh code spread data symbols 120 are output from exclusive-OR combiner 118 at a fixed chip rate (e.g., 1.2288 Mchips/s).

The Walsh code spread data symbols 120 are provided to an input of two exclusive-OR combiners 122 and 128. A pair of short PN sequences (i.e. short when compared to the long PN sequence used by the long PN generator 110) are generated by I-channel PN generator 124 and Q-channel PN generator 130. These PN generators 124 and 130 may generate the same or different short PN sequences. Exclusive-OR combiners 122 and 128 further spread the input Walsh code spread data 120 with the short PN sequences generated by the PN I-channel generator 124 and PN Q-channel generator 130, respectively. The resulting I-channel code spread sequence 126 and Q-channel code spread sequence 132 are used to bi-phase modulate a quadrature pair of sinusoids by driving the power level controls of a the pair of sinusoids. The sinusoid's output signals are summed, bandpass filtered, translated to an RF frequency, amplified, filtered and radiated by an antenna to complete transmission of USER 1 data bits 100 via a communication channel.

FIG 2 shows the typical configuration used to accommodate two users. In essence, the apparatus of FIG 1 is replicated for the second user. Each apparatus' quadrature output signals are combined together by combiner 134 prior to modulation and radio transmission. Each user always uses a distinct Walsh code to spread its information 114. This is true even when the input data 100 rate is reduced, for example, to 4.8 kbps max. As previously mentioned, repetition coding expands this data rate to an effective

9.6 kbps rate so that the Walsh code spreading always results in the desired 1.2288 Mchips/s desired output. Thus, to transmit the information of any two users, for example USER 1 and USER 2, requires the use of two (of the maximum 64) Walsh codes.

FIG. 3 generally depicts, in block diagram form, a preferred embodiment spread spectrum transmitter apparatus which performs time division multiplexing of spreading codes for two users in accordance with the invention. The transmitter apparatus of FIG. 3 improves upon the prior art spread spectrum transmitter shown in FIG. 2 when used for transmitting the information of two users. As can be seen, FIG. 3 does not require the duplication of transmitter hardware to transmit information for two users while only requiring a single spreading (Walsh) code for transmission of the information.

Referring to FIG. 3, USER 1 data bits 301 and USER 2 data bits 302 enter respective error correction coders 303, 306. Time division multiplexing of spreading codes is accomplished by coding first user data 301 to produce coded first user data 304 and coding second user data 302 to produce coded second user data 307. Coded first user data 304 and coded second user data 307 are then multiplexed in at least partially non-overlapping time periods by multiplexer 312. The partially non-overlapping time periods are given by $1/f_c$, where f_c is the frequency of a clock signal 309 input into multiplexer 312. The multiplexed coded first user data and the coded second user data is then spread, by spreader 315, with a common spreading code (W_i) to create modulator data 316. Important to note is that only a single, common orthogonal spreading (or Walsh) code is required in this implementation.

Modulator data 316 is then scrambled by scrambler 318. In the preferred embodiment, scrambler 318 scrambles modulator data 316 with a pseudo-noise scrambling sequence. The scramble modulator data 319 is then conveyed to a modulator where it is transmitted via a wireless interface to a destination. In the

preferred embodiment, the circuitry of FIG. 3 and the method thereof may be implemented in either a base-station or a mobile unit compatible with the spread spectrum communication system.

It is well known in the art to synchronize the multiplexing of multiple data streams on an alternating basis to the Walsh spreader. Of course, this method and synchronization information must also be known at the receiver (i.e., the destination) to allow successful decoding of the information. DS-CDMA systems have very well established clock signals, through use of synchronization sequence and PN tracking, thus no additional timing information is necessary. Again, through this method, it is seen that only a single Walsh code is utilized for the transmission of two user's information.

FIG. 4 shows a timing chart of how a single Walsh code, W_1, is shared for transmitting the information of two users. In alternate transmission blocks, the information for USER 1 and then USER 2 is repetitively transmitted in partially non-overlapping time periods given by f_c.

While the invention has been particularly shown and described with reference to a particular embodiment, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention.

What I claim is:

Claims

1. A method of time division multiplexing the use of spreading codes in a spread spectrum communication system, the method comprising the steps of:

time division multiplexing first and second user information in at least partially non-overlapping time periods to produce multiplexed first and second user information; and

spreading the multiplexed first and second user information with a common spreading code.

2. The method of claim 1 wherein the common spreading code is a common orthogonal spreading code.

3. A method of time division multiplexing the use of spreading codes in a spread spectrum communication system, the method comprising the steps of:

coding first user data to produce coded first user data;

coding second user data to produce coded second user data;

multiplexing the coded first user data and the coded second user data in at least partially non-overlapping time periods to produce multiplexed coded first user data and the coded second user data; and

spreading the multiplexed coded first user data and the coded second user data with a common spreading code to create modulator data.

4. The method of claim 3 further comprising the steps of:

scrambling the modulator data with a pseudo-noise scrambling sequence; and

transmitting the scrambled modulator data via a wireless interface to a destination.

5. The method of claim 3 wherein the method is implemented in either a base-station or a mobile unit compatible with the spread spectrum communication system.

6. An apparatus for time division multiplexing the use of spreading codes in a spread spectrum communication system; the apparatus comprising:

means for time division multiplexing first and second user information in at least partially non-overlapping time periods to produce multiplexed first and second user information; and

means, coupled to the means for time division multiplexing, for spreading the multiplexed first and second user information with a common spreading code.

7. The apparatus of claim 6 wherein the common spreading code is a Walsh code.

8. The apparatus of claim 6 wherein the apparatus is implemented in either a radio compatible with the spread spectrum communication system.

9. An apparatus for time division multiplexing the use of spreading codes in a spread spectrum communication system, the apparatus comprising:

a first coder for coding the first user data to produce coded first user data;

a second coder for coding second user data to produce coded second user data;

a multiplexer, coupled to the first and second coders, for multiplexing the coded first user data and the coded second user data in at least partially non-overlapping time periods to produce multiplexed coded first user data and the coded second user data;

a spreader, coupled to the multiplexer, for spreading the multiplexed coded first user data and the coded second user data with a common spreading code to create modulator data.

10. The apparatus of claim 9 further comprising:

a scrambler for scrambling the modulator data with a pseudo-noise scrambling sequence; and

an amplifier for transmitting the scrambled modulator data via a wireless interface to a destination.

FIG. 1

— PRIOR ART —

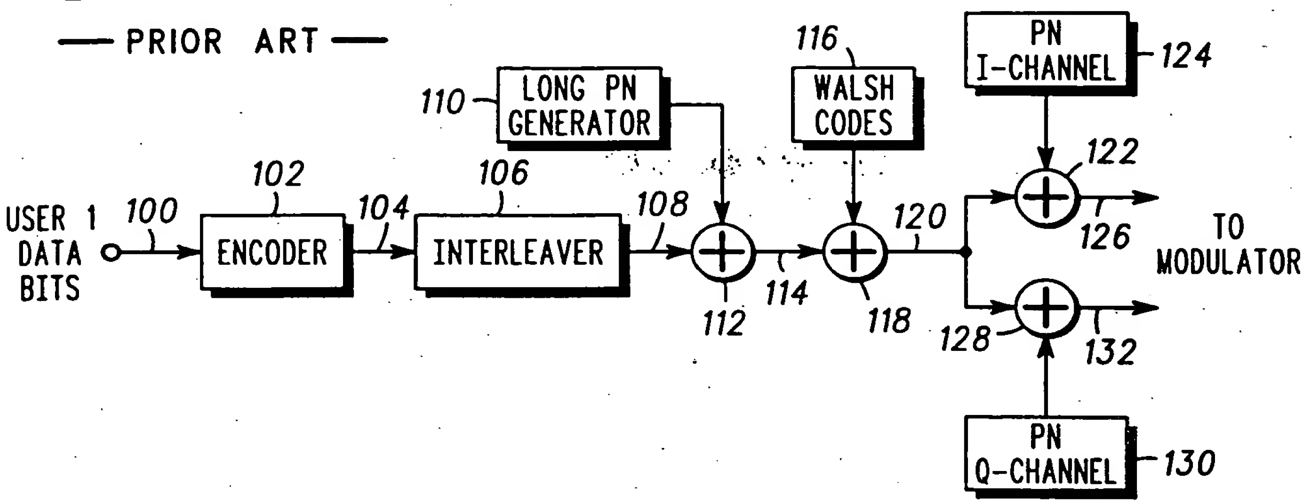


FIG. 2

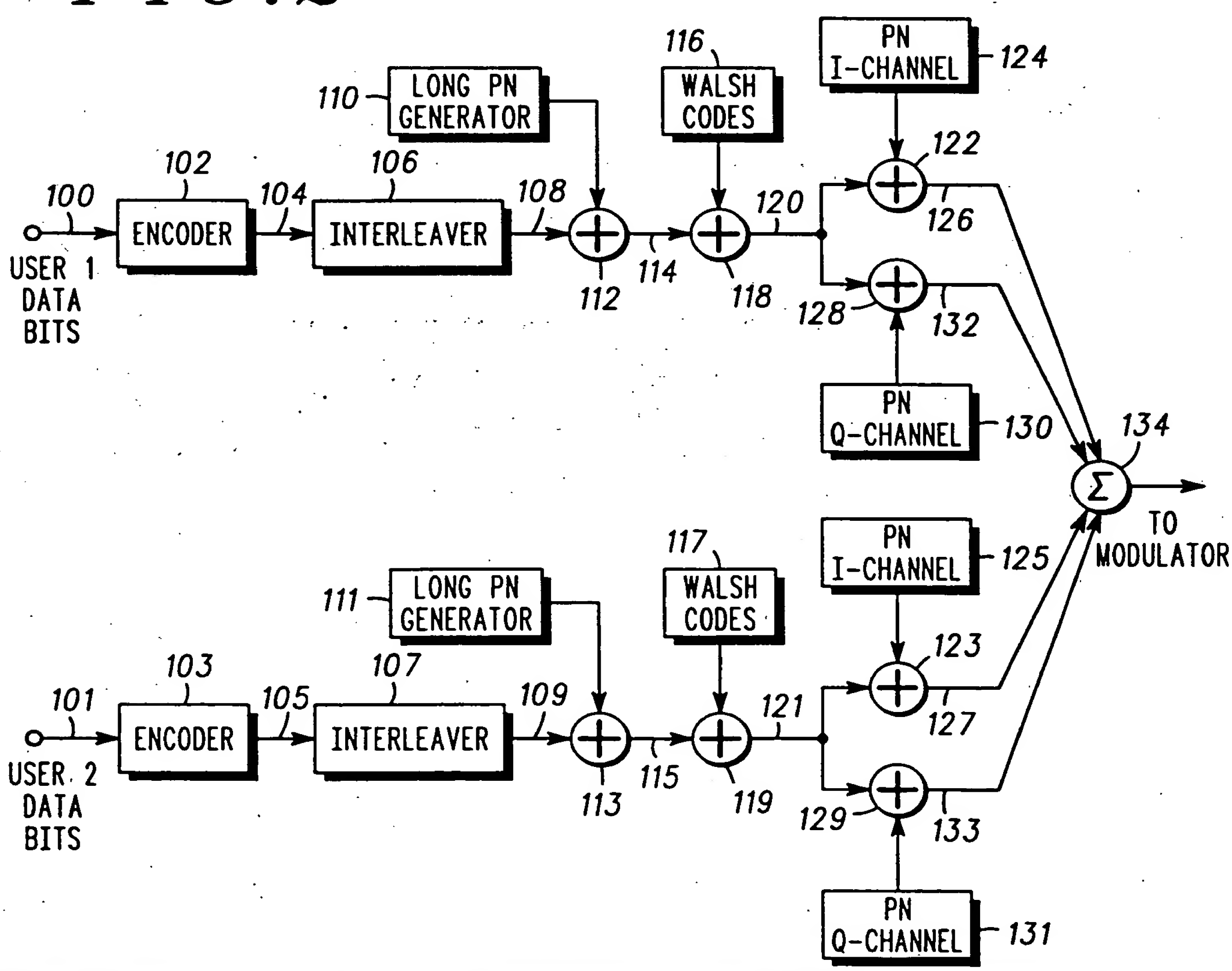


FIG. 3

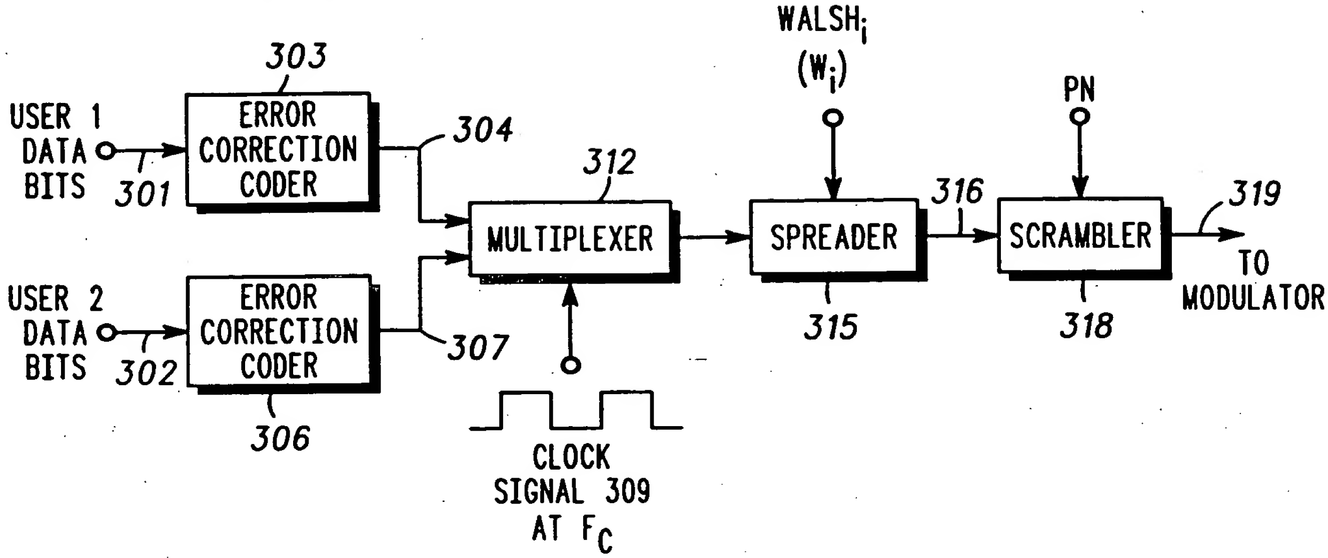
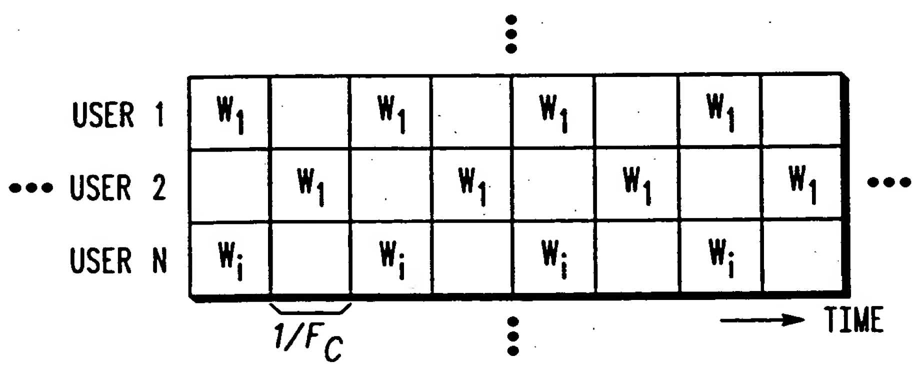

USER 1 DATA BITS
301
ERROR CORRECTION CODER
303
304
USER 2 DATA BITS
302
ERROR CORRECTION CODER
306
307
MULTIPLEXER
312
CLOCK SIGNAL 309 AT F_C
WALSH$_i$ (W_i)
SPREADER
315
316
PN
SCRAMBLER
318
319
TO MODULATOR

FIG. 4


USER 1
USER 2
USER N
W_1
W_i
$1/F_C$
TIME

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/00233

A. CLASSIFICATION OF SUBJECT MATTER

IPC(5) :H04J 3/22
US CL : 370/18, 21, 22, 77, 112; 375/1
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 4,455,651 (BARAN) 19 JUNE 1984, col. 8, line 6 to col. 9, line 4.	1-10
Y	US, A, 5,103,459, (GILHOUSEN ET AL) 07 APRIL 1992, col. 33, lines 54-66.	1-10
Y	US, A, 5,239,540 (ROVIRA ET AL) 24 AUGUST 1993, col. 5, lines 3-28.	1-10

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